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TECHNICAL NOTE

ENERGY CONSERVATION IN GREENHOUSES III. PERIMETER INSULATION TO REDUCE HEAT LOSS THROUGH THE FLOOR

INTRODUCTION

Heat is lost through the soil of a greenhouse in two ways. In the center of a greenhouse, it is transmitted straight down, deep into the ground, which remains cooler year-round. Little can be done about this type of heat loss, but, in a greenhouse experiencing greater energy loss in other parts of its structure, its impact is negligible given that it represents only 1-2% of the total loss. Greater losses occur at the edge of the greenhouse. At the greenhouse perimeter, heat is conducted through the soil and is eventually released into the outside air. In an otherwise well-insulated, double poly greenhouse, this perimeter loss may account for 7-10% of the total loss. However, this is difficult to determine, as any significant amount of snow cover around the outside perimeter acts as an insulator.

Perimeter heat loss, as shown in Figure 1(a), occurs in paths consisting of concentric circles (Anon. 1972, Boileau and Latta 1968). The rate of heat loss is inversely proportional to the distance the energy must travel from its source; therefore, the coldest soil regions in a greenhouse are found close to the greenhouse wall and footing course, where the "pathlengths" are the shortest. The greater the distance from the wall, the more rapidly does the rate of energy loss decrease; thus, it is almost constant after a distance of approximately 7 ft., where deep ground losses predominate (Fig. 1(b). The bulk of heat loss occurs within 4 ft. of the greenhouse wall or footing course. Within a 2 to 4 ft. radius of the the perimeter, the through-soil heat loss ranges from slightly over 65% at the inner radius to approximately 85% at the outer radius.

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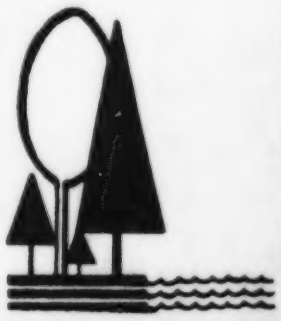

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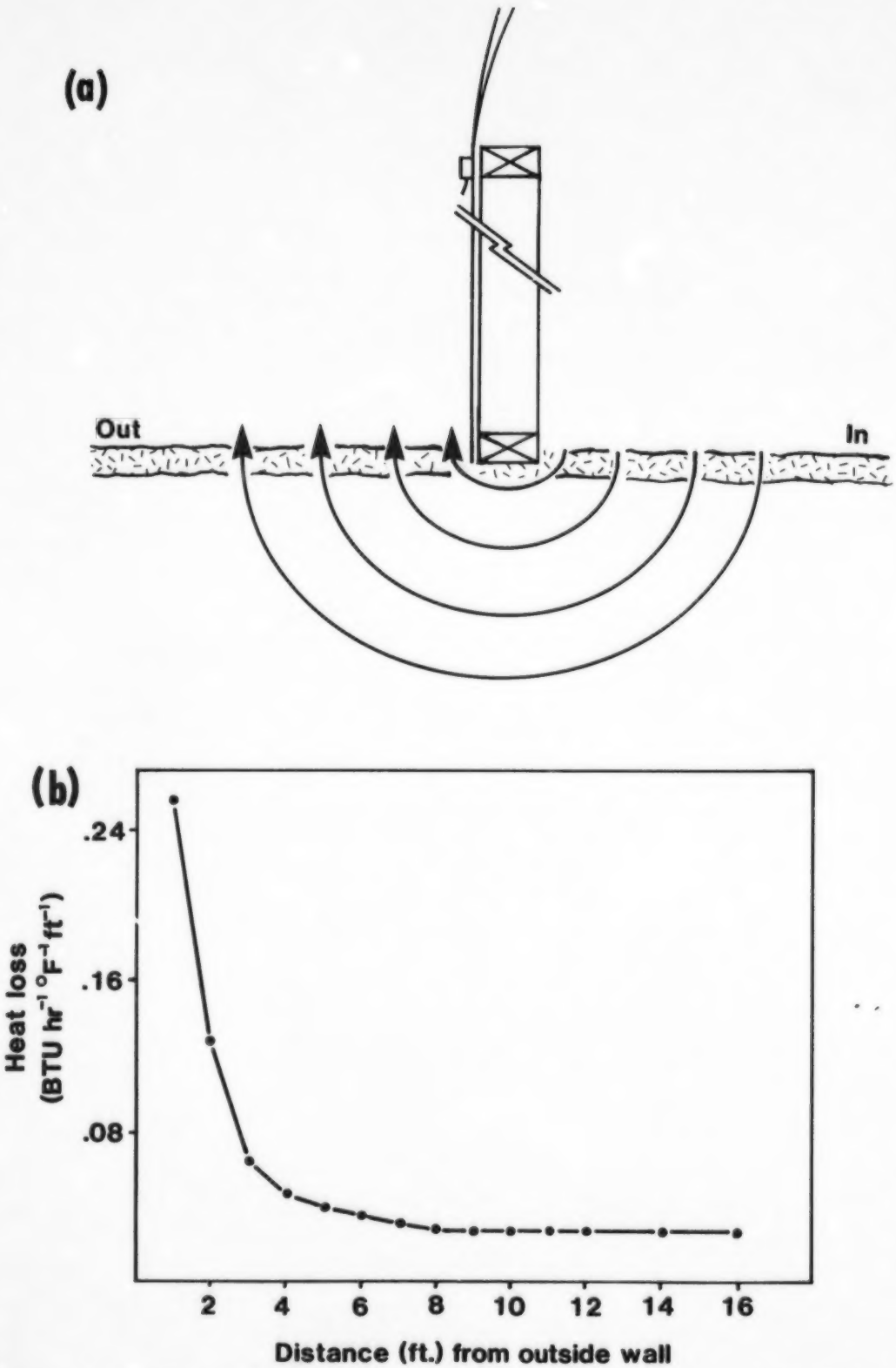

Figure 1. Perimeter heat loss: (a) occurs in paths of concentric circles; and (b) deep ground losses predominate after a distance of 7 feet.

PERIMETER INSULATION

The type of insulation used is important. Only materials which do not absorb significant amounts of water should be used, as water is a good heat conductor, and wet insulation will have a much lower R-value. The insulation chosen must also resist compression from backfilling and soil movement resulting from nearby nursery vehicle traffic. The most commonly used material is extruded, polystyrene sheet (EPS type 4).

The depth to which the perimeter walls are insulated is another important consideration. Most rigid insulation is supplied in 2 or 4 ft. widths and various thicknesses. As the rate of heat loss does not remain uniform with distance from or under the perimeter wall, thick insulation applied to a shallower depth is actually more effective than the same amount of insulation of half the thickness applied to twice the depth. This is demonstrated in Table 1. Disturbing the soil to a depth of 4 ft. may be inadvisable where posts or anchors are used, and deeper excavation is more costly, so the shallower depth is on all counts preferable.

Placement of the insulation depends on several factors, including: type of insulation, type of footing course, whether application is being done as a retrofit, and whether there are interior perimeter walkways (as opposed to extending the crop out to the periphery, which will increase ground moisture content due to irrigation). Water-saturated soil is almost twice as conducive as dry soil. Therefore, less heat will be lost if perimeter insulation can be applied at an angle on the interior, or if a concrete walkway is present to deflect water away from the soil closest to the sidewall. Alternatively, where adequate drain tile has been installed at the perimeter and a footing course is present, vertically applied insulation will be easier and cheaper. In retrofit applications, the insulation may have to be installed at a slightly less than horizontal angle in order to avoid disturbing the soil supporting the greenhouse sills, and on the outside of the wall so that benches and interior flooring do not have to be moved. In all cases, insulation should extend up to the point where the greenhouse wall emerges from the soil and the exposed edge of the insulation should be covered with metal flashing to prevent mechanical damage and degradation by sunlight.

Table 1. Reduction of subsoil perimeter heat loss as a function of insulation thickness and the depth to which it is applied (using EPS type 4).

Thickness (in)	Depth (ft)	% Reduction
1	2	31
2	2	41
1	4	36
2	4	49

OTHER CONSIDERATIONS

Some greenhouse operators, even if they are spring growing and cannot justify the investment solely on the basis of energy dollar savings, may wish to consider installing perimeter insulation. Cold perimeter temperatures are detrimental to germination and growth, especially if container stock is grown on low pallets, or is in direct contact with the greenhouse floor, and if root zone heating cannot be used. In cold conditions, germination is slower and percent germination is lowered (Hallett, 1983). Also, sub-optimal temperatures slow top growth and lead to poor root development. Therefore, it may be desirable to use perimeter insulation, justifying its use primarily in terms of increased crop quality and better utilization of the greenhouse periphery rather than energy conservation. This insulation, if applied properly, should last for the lifetime of the greenhouse and will require no maintenance. Ideally, it should be installed during initial construction or as a retrofit.

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